The Third Phase for the Sudbury Neutrino Observatory, Neutral Current Detectors

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The Sudbury Neutrino Observatory (SNO) detects ^{8}B solar neutrinos through the reactions:

$$\begin{array}{lll} \nu_e + \mathrm{d} \;\rightarrow\; \mathrm{p} + \mathrm{p} + \mathrm{e}^- & & (\mathrm{CC}), \\ \nu_x + \mathrm{d} \;\rightarrow\; \mathrm{p} + \mathrm{n} + \nu_x & & (\mathrm{NC}), \\ \nu_x + \mathrm{e}^- \rightarrow\; \nu_x + e^- & & (\mathrm{ES}). \end{array}$$

The CC reaction only involves electron-type neutrinos, while the NC reaction is equally sensitive to all active neutrino flavors ($x = e, \mu, \tau$). The ES reaction is sensitive to all flavors as well, but with reduced sensitivity to ν_μ and ν_τ. These three reactions allow SNO to determine the electron and non-electron active neutrino components of the solar flux [1]. This note briefly summarizes the most recent NC results from SNO and presents the plan for the final phase of SNO, the Neutral Current Detectors (NCDs).

SNO [2] is a water Cherenkov detector located at a depth of 6010 m of water equivalent in the INCO, Ltd. Creighton mine near Sudbury, Ontario, Canada. The detector uses ultra-pure D_2O contained in a transparent acrylic spherical shell to detect solar neutrinos. Cherenkov photons generated in the D_2O are detected by 9456 PMTs mounted on a stainless steel geodesic designed, constructed and installed by the LBNL group. The geodesic is immersed in ultra-pure H_2O to provide shielding from radioactivity.

The experiment has concluded its second phase, with a total of 391 live days with NaCl dissolved in the D_2O target[3]. These data were recorded between 26 July 2001 and 28 August 2003. The analysis procedure was similar to that described in [4], but included a significantly enlarged data set, enhanced background and signal analysis. These results are presented in a separate report included herewithin. Figure 1 shows the deduced flux of non-electron flavor active neutrinos vs the flux of electron neutrinos.

The SNO experiment was then modified to prepare for its third phase of operation. The NaCl was removed by reverse osmosis purification and the array of independent array of 40 ^{3}He neutron detectors were installed in the central D_2O volume. This array and the entire detector were recently commissioned and the third data set for SNO commenced in January 2005. The NCD phase of SNO will run through the calendar year 2006.

Use of the NCDs and the independent determination of the neutral current flux within the detector will to a great extent break the covariances in the analysis and extraction of the charged current and neutral current fluxes. This will result in SNO yielding the most precise determination of the these fluxes and consequently provide the most robust information on the neutrino flavor transformation and neutrino mixing angle θ_{12}.

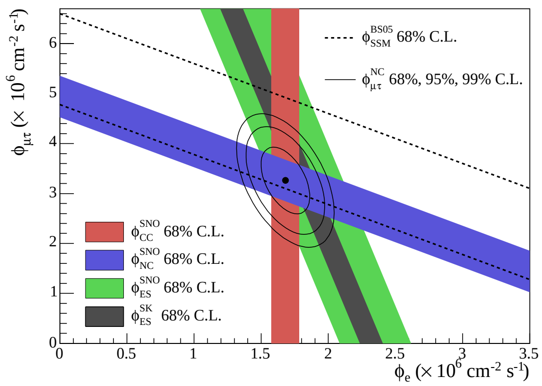

FIG. 1: Flux of ^{8}B solar neutrinos which are μ or τ flavor vs flux of electron neutrinos deduced from the three neutrino reactions in SNO. The diagonal bands show the total ^{8}B flux as predicted by the SSM and that measured with the NC reaction in SNO (solid band). The bands intersect at the fit values for ϕ_e and $\phi_{\mu\tau}$, indicating strong evidence for neutrino flavor transformation.

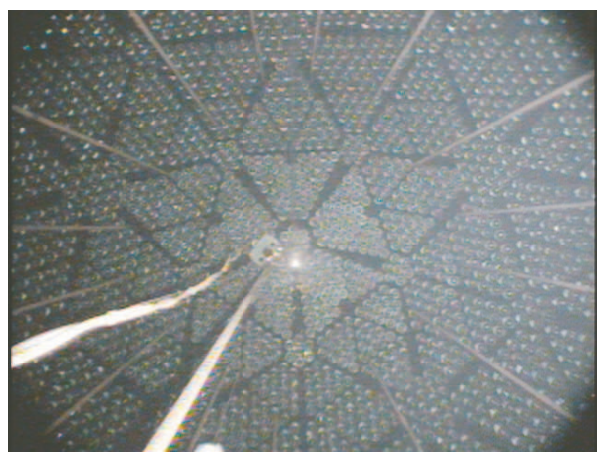

FIG. 2: The inner SNO volume with the NCD array installed. The NCDs are the vertical Ni tubes $\sim$ 5 cm in diameter.

[1] H.H. Chen, Phys. Rev. Lett. **55**, 1534 (1985).
[2] Boger, J. *et al*, Nuc. Inst. Meth. **A449**, 172 (2000).
[3] B. Aharmim *et al.*, P.R.D. , (2005).
[4] Q.R. Ahmad *et al.*, Phys. Rev. Lett. **92**, 181301 (2004).
[5] M. Dragowsky *et al.*, Nuc. Inst. Meth. **A481**, 284 (2002).